THE POLE AND THE AUSTRALIAN PERMIAN

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In 1997 the bicentenary of the birth of a distinguished scientist, Sir Paul Edmund Strzelecki (1797–1873) was celebrated. Strzelecki spent four years (April 1839–April 1843) in Eastern Australia, mapping the rocks and collecting many rock, mineral and fossil specimens, particularly from two important Permian successions: (a) in the Sydney Basin; and (b) in Tasmania.

Strzelecki was geologising in Australia when Sir Roderick Murchison had begun his study of Russian geology that was to see the introduction of the term Permian into stratigraphic use.

Strzelecki's time in Australia also coincided with the arrival of long-time resident geologist Rev. W. B. Clarke, the ill-fated explorer Ludwig Leichhardt and short term visits by James Dwight Dana and J. Beete Jukes, all of whom contributed to unravelling the story of the Australian Permian.

Initially Strzelecki's subdivision of the Australian rocks was made on the basis of recognising 'epochs' (using an essentially descriptive method). Strzelecki defended this method in his book *Physical Description of New South Wales and Van Diemen's Land*, published in 1845, stating that geological nomenclature (i.e. the modern stratigraphic terminology) applied to Australian rocks at that time would imply 'identities with eras of deposition in other parts of the world'.

Although his book was essentially complete when he left Australia Strzelecki modified it before publication in England in 1845 by the addition of detailed descriptions of the fossils he had collected. The fossil plants and invertebrates were studied by John Morris, William Lonsdale and George B. Sowerby, while Richard Owen examined the marsupial remains.

Strzelecki was happy to place the older material in the Palaeozoic, although Morris more specifically described the fossil plants as being Carboniferous. The term Permian did not appear in this book, which was published about the time Murchison was formally defining the period. Of the early geologists, Dana, the short-term American visitor, was first to accept the Permian age of much of the succession in the Sydney Basin, publishing his results in 1849.

Aspects of the Australian Permian story up to the 1880s can be traced from the discovery of fossils by Robert Brown in 1804, their description in the 1820s, through the work of Thomas Mitchell, Strzelecki, Jukes, Clarke and Dana, Frederick M'Coy and later by Robert Etheridge Jnr in Australia, and by European researchers such as Alceste D'Orbigny, L. De Koninck and Ottakar Feistmantel.

Strzelecki's work was the first attempt to establish a stratigraphy for Australia. His epic travels, his mapping, including some excellent cross-sections, combined with his astute collecting, made a significant contribution to Australian geology, and to the study and understanding of what later were recognised as Permian rocks.

In 1997 we celebrated the bicentenary of the birth of a distinguished scientist, Sir Paul Edmund Strzelecki (1797–1873) (Fig. 1). Strzelecki spent four years (April 1839–April 1843) in Eastern Australia, mapping the rocks and collecting many rock, mineral and fossil specimens, particularly from two important Permian successions: (a) in the Sydney Basin; and (b) in Tasmania.

Strzelecki was geologising in Australia when Roderick Murchison had begun his study of Russian geology that was to see the introduction of the term Permian into stratigraphic use. In 1843 Murchison pursued the Permian rocks in Germany, accompanied by John Morris who was later to play an important part in Strzelecki's story. This paper outlines Strzelecki's geological work in Australia, discusses his geological background and examines his place in the development of the understanding of the Australian Permian.

THE BACKGROUND TO PAUL EDMUND STRZELECKI

Paul Edmund Strzelecki was born in June 1797 at Gluzyma, near Posnan, Poland, and left his homeland for ever in 1825. Despite rumours, he does not appear to have attended any university, but a good basic education, a quick mind, hard work and a pleasant personality that gave him easy access to important and influential people, enabled him

Fig. 1. Paul Edmund Strzelecki.

to educate himself to a high level. He became interested in agriculture, soils and geology before he left Poland, but developed his knowledge in these areas by travel through western Europe, particularly France and the United Kingdom, where he felt particularly at home. At this time he was certainly recording his observations and other data in notebooks, but with no apparent object in view.

On 8 June 1834 Strzelecki set out on a journey that took him first to the New World and on to Australia. Whether it was just wanderlust or part of a definite plan is uncertain, but, at that time, he probably had nothing more than just a desire to see the world. Although he spent more than two years in the Americas we don't know much of his travels in North and South America, although Paszkowski (1997) has attempted to fill in this gap. Certainly his travels were extensive and they gave him increased knowledge of mineral deposits, which he saw in the Great Lakes region of Canada, where he was for more than a year (Strzelecki 1847). He travelled the Eastern Seaboard from New York, south to Charleston, and north to Boston and Niagara. He also went to Cuba and Mexico and up the Mississippi River.

From the USA he travelled to Brazil, including its mineral-rich provinces, crossed the Andes to Chile (quite a feat in those days when Charles Darwin was visiting the same region), then travelled north to California, taking the chance to visit mining fields whenever possible. He was also shamed by 'man's inhumanity to man' when seeing slave ships and slavery (Strzelecki 1845).

His personality gained him the offer of travel through the islands of the Pacific on board HMS *Fly* (Captain Russell Elliott), and his visit to the big island of Hawaii saw his first published geological article, a description of Kiluaea volcano, climbed about the same time by James Dwight Dana of the American Wilkes Expedition.

Strzelecki (1838) wrote '... the sunken furnace of Kirauea ... presenting one of the sublimest scenes of nature, the interest inspired ... can only be rivalled by ... awe. It is no small effort to recall the attention from the vague contemplation of that scene to the calm investigation of facts and phenomena before us.' Strzelecki goes on to give details of the size of the crater, the care required to get down towards the lava, the indication of variations in activity enshrined in the walls of the crater, and the specific features of six active small vents.

'No pen or pencil could adequately describe the stupendous grandeur of that ceaseless impetuosity and fury of the incandescent matter which is produced in these reservoirs by the violence and intensity of heat; or of those fierce and glowing waves which, continuing to beat and splash against the walls of the reservoirs, produce a floating froth spun out by currents of air, in a form of capillary glass, similar to that of a floating gossamer.' This description was noted by Dana who was still referring to it as late as 1891.

Strzelecki saw more evidence of volcanic activity, but now extinct, on Tahiti, before travelling on to New Zealand. From the Bay of Islands he saw a little of the geology of the northern part of the North Island, before reaching Sydney in April 1839.

Details of Strzelecki's life can be found in a number of publications, including Rawson (1953), Heney (1961), Babicz et al. (1978) and more recently Paszkowski (1997), and will not be given here.

AUSTRALIAN TRAVEL

Strzelecki spent three months in Sydney making friends, before setting off to the Blue Mountains and beyond to gain his first real impressions of Australian geology. He and his companions had a very difficult physical time in the deep gorges of the Blue Mountains, which at that time were virtually unexplored, but the apparent consistency of the geology led Strzelecki to remark that the geology there was tame, which it could be regarded as being in comparison with the Andes, and even Hawaii. At this time Strzelecki was inclined to think the sandstones of the Blue Mountains were very young.

In his visit to the region Strzelecki gives a graphic description of a romantic landscape '... yawning chasms, deep winding gorges, and frightful precipices. Narrow, gloomy, and profound, these stupendous rents in the bosom of the earth are enclosed between gigantic walls of a sandstone rock, sometimes receding from, sometimes frightfully overhanging the dark bed of the ravine, and its black silent eddies, or its foaming torrents of water. Everywhere the descent into the deep recess is full of danger, and the issue almost impracticable. The writer of these pages, engulfed in the course of his researches, in the endless labyrinth of almost subterranean gullies of Mount Hay and the River Grose, was not able to extricate himself and his men until after four days of incessant fatigue, danger, and starvation. The ascent of Mount Hay, when these difficulties are once surmounted, repays richly the exertion and fatigues which it entails.'

His travels west and northwest took him into areas where Lower Palaeozoic rocks were exposed. And on this trip he noted the existence of gold, one matter which was to concern him some fifteen or so years later. In addition to his writing Strzelecki also put down his geological observations on a large map and drew large-scale cross-sections to explain the geology of the region.

Returning to Sydney, Strzelecki met Rev. W. B. Clarke (Fig. 2) and J. D. Dana (Fig. 3), both newly arrived in the colony, Clarke to become the doyen of Australian geology over the next forty years, while Dana spent only several months in the colony (but they were very productive months). The ships of the Wilkes expedition (of which Dana was a scientific member) had entered Sydney Harbour at night and caused a sensation when they were observed early next morning, near panic being averted as the worthy citizens learnt it wasn't an invading Russian Fleet! The three geologists got together (although it is not absolutely established that Dana was there) and apparently hugely enjoyed discussion and the wine and food at a big party reception for the expedition, Strzelecki excelling with his reply to a toast to Poland and Freedom.

It seems to have been about this time that Strzelecki decided there was an opportunity for himself to make a contribution to science by studying the geology of New South Wales, and particularly by preparing a map to show the variations which occurred. As mentioned above he had in fact begun the map, and had prepared a cross-section from Bathurst to Sydney. Although the topographic base maps of the day were quite sketchy, Thomas Mitchell, Surveyor-General, and his assistants having only been able to survey the region near Sydney to any degree of accuracy, Strzelecki was able to work on a scale of 1:250 000.

Through the social network Strzelecki found that James Macarthur of Parramatta, son of Hannibal Macarthur, was planning to journey to the coast near Bass Strait looking for new pastures (in the area now known as Gippsland). On 27 December 1839 Strzelecki left Camden Park, the seat of another member of the Macarthur clan, and travelled through the sparsely settled areas to the Murrumbidgee River and on to Ellerslie Station near Adelong. Here, in February 1840, Macarthur and James Riley, with several servants, joined him. Writing to his friend Thomas Brook in London from Ellerslie Riley noted 'There is a Polish Count—a great geologist and very scientific. From this [Ellerslie] we have the head of the Hume thence across to Lake Omeo. We then follow the snowy mountains down the eastern side to Wilsons Promontory or Corner Inlet where we intend to form our stations' (Riley papers 1840). A rough sketch map (an original by Strzelecki, dated 26 June 1840), lodged with the Riley papers, shows the route marked in red, with names, including Mt Buller, Mt Gisborne, Mt Gibbo, Mt Kosciuszko), signed on the back 'to his fellow monkey eater, Riley'.

Travelling south to the Murray River and what is now Victoria, Strzelecki was attracted by the high country he had been seeing to the east, and persuaded Macarthur to divert a little. From the Upper Murray Strzelecki made an onslaught on what he believed was the highest mountain, naming it Kosciuszko for the Polish patriot, because of the resemblance of the mountaintop to a monument to Kosciuszko built near Cracow. The arguments that have continued about which peak Strzelecki conquered and other aspects of the early exploration of the high country have been discussed by Clews (1973), Andrews (1979, 1991), Rawson (op. cit.), Paszkowski (op. cit.) and others, and

Fig. 2. Rev. W. B. Clarke (Mitchell Library).

will not be further considered here. However Strzelecki certainly made the public aware of the high country, the Australian Alps.

The expedition continued south, crossing some very rough country to Lakes Entrance, but they encountered most difficulty west from here (now the Strzelecki Ranges) where dense scrub and shortage of water hindered their progress, and they were in desperate straits, surviving on native flora and fauna (including koalas—'Monkeys')

Fig. 3. J. D. Dana.

when they eventually reached the settled area east of Port Phillip (now Melbourne) in May 1840 (Fig. 4).

Strzelecki's report of the journey (in which he named the area Gippsland for Governor Gipps) attracted considerable attention in Port Phillip and in Sydney, when news of their safe arrival reached it. Again there was controversy, this time fairly rapidly, as there were already settlers in Gippsland, and they were not happy that their 'paradise' was being revealed, and might attract others to share the potential wealth.

The report also shows Strzelecki's attachment to a rather Wernerian approach to geology, what is better called geognosy ('the observational science which considers the arrangement of minerals in the crust and their topographic occurrences' [Breislak], see Branagan 1986a). This contrasts with a geological approach which uses physics and chemistry to arrange the factual data into a complex history of the earth. The significance of topography in the geognostic scheme must be noted, as elevation was still judged by many to be a measure of age, the highest ranges containing cores of ancient rock, so Strzelecki was very much committed to making barometric readings as often as possible, and also to drawing accurate cross-sections showing both elevation and rock types (see also Strzelecki 1842a).

Strzelecki listed eight substances of possible economic value of which he obtained specimens. They were gold, silver, iron, coal, clays, lime, serpentine and earthy salts (including 'hair salt of Werner'). He recognised four geognostic divisions and classed them as primary, transition, secondary and tertiary, noting that the main range which divides the eastern from the western waters may be fairly considered the great axis of perturbation.

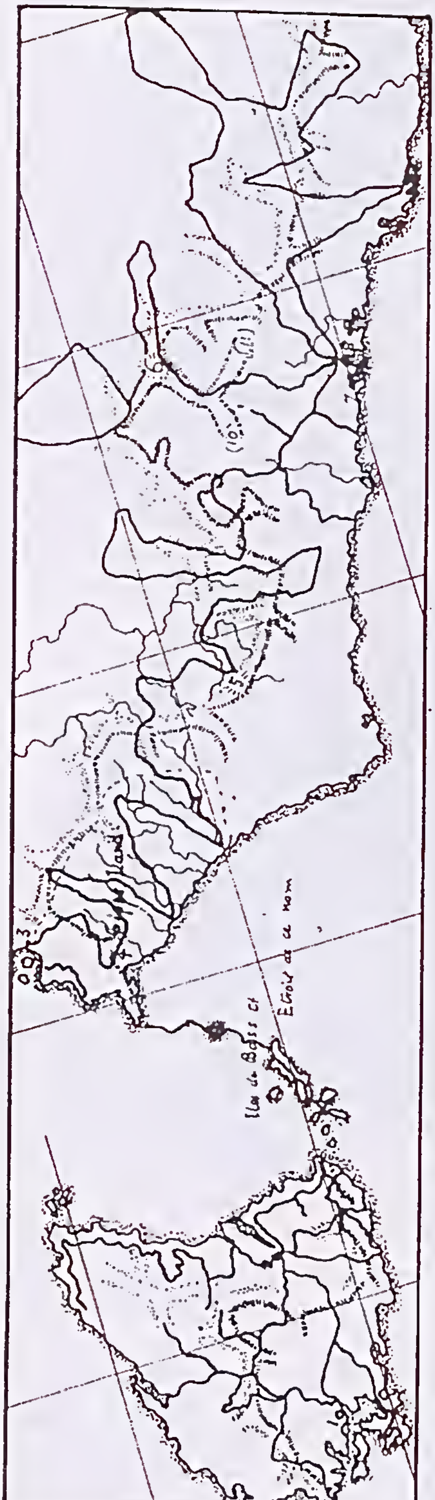

Fig. 4. Strzelecki's route through Eastern Australia.

Reading this report in detail (see Branagan op. cit.) we can see that Strzelecki recognised a number of geomorphic regions which were largely dependent on rock type and structural relationships. He recognised that deformation of the region had produced characteristic north–south trends and attributed them to episodic convulsions at different locations and times along a single axis. He felt that igneous activity had played an important part in such convulsions. These observations served to confirm his faith in 'the great order of superposition … in perfect identity to that observed on the rest of the globe'. He was later cautiously to recant on this geological article of faith. To gather these observations into a unified scheme he devised his own complex system of colors and patterns (symbols) to show the information on rock type (and to a lesser extent structure) on his map and sections (see later).

Strzelecki's report (Strzelecki 1840) was published in part by the *Port Phillip Herald*, concentrating on the physical aspects of the landscape and omitting the rather geognostical aspects, but his views were attacked by Dr A. F. A. Geeves in a lecture reported by the rival *Port Phillip Gazette* as 'a most entertaining and interesting discourse, although only an introductory one upon the science of Geology' (Branagan op. cit.).

TASMANIA

It was inevitable that Strzelecki should be attracted to Tasmania (which was then called Van Diemen's Land), from Melbourne and he went to Port Sorell (near Launceston) in July 1840. He did not leave Tasmania until September 1842, criss-crossing the island, leaving only the inaccessible far southwest and the Pieman River area unvisited. Some of the Bass Strait islands were also examined. Strzelecki made many friends in Tasmania. In Sydney he had already met and charmed Lady Jane Franklin (Fig. 5), wife of the Governor (Franklin 1840), Sir John (Fig. 6), so had a ready entrée into Tasmanian society. Friends included Joseph Milligan, Irish medic, public servant and naturalist, Robert Campbell Gunn, an outstanding naturalist, and expatriates like Mr Schager, a German who worked for the Van Diemen's Land Company, who was also collecting 'natural curiosities for the philosophers of Berlin'.

Strzelecki accompanied Governor Franklin to Port Arthur early in 1841. In May 1842 Franklin was keen to call on Strzelecki's expertise to check the location of Lake St Clair, and Frenchman's Cap (as Franklin and his wife had travelled to

Fig. 5. Lady Jane Franklin (Mackaness 1955).

Macquarie Harbour without a sextant). Franklin expressed his regret (24 May 1842) that he had been unable to get to Launceston to look at Strzelecki's geological map, and to talk about his work 'which I hear and know is unremitting'. An interesting analysis of Strzelecki's geological work in Tasmania is given by A. N. Lewis (in Havard 1940).

Strzelecki was in Tasmania when there was considerable interest in the search for profitable coal mines. Coal measures of Triassic age were being (relatively) extensively developed at Saltwater Creek, after the earlier geological mapping by another Pole, John Lhotsky. Strzelecki was the first to publish observations on faulting of Tasmanian coal seams, and on the coking effect of dolerite heating coal (seen at Recherche Bay and Southport) (Strzelecki 1842b). He was also the first person to attempt to correlate coal seams (one at Jericho with one at Jerusalem) (Bacon & Banks 1989).

Of the offshore islands Strzelecki apparently paid a brief visit to Maria Island, where dolerite

Fig. 6. Sir John Franklin (from a portrait by Negenev).

'overlies' fossiliferous rocks. In 1834 having been provided with specimens by surveyor George Frankland, Baron von Hügel had commented that 'this island consists entirely of fossilized sea shells' (Clark 1994), something of an exaggeration, but the Permian beds there are certainly fossil-rich. Von Hügel himself also noted 'a black limestone containing many fossilized shells occurs round New Norfolk and large lumps of petrified wood resembling agate have been found 15 to 20 miles inland', but his geological comments drew little attention.

COMPLETING THE MAP, SECTIONS AND BOOK

All the time Strzelecki's map was growing in extent and detail, and seventeen cross-sections were being drawn. In October 1841 arrangements were made for him to use the Government Cottage in Launceston. By mid-1842 he was ready to sit down and write his thoughts about East Australian geology and related matters. When he left Tasmania in September 1842 he had his draft manuscript, which accompanied him when he moved north

Fig. 7. Phillip Parker King (Mitchell Library).

again. He went first to Sydney and then apparently made a quick, but important visit to the Illawarra coast (Organ 1997) where he collected a variety of fossils. He then travelled to the Newcastle coalfield and to the haven of *Tahlee*, the home of Captain Phillip Parker King (Fig. 7) in Port Stephens, north of Newcastle. King advised him about his manuscript (as he was later to do for Ludwig Leichhardt), and discussed the map and sections. King showed the work to Governor Gipps and put forward the idea of government funding to publish the map, but Gipps was not optimistic.

It seems unfortunate that Strzclecki and Ludwig Leichhardt (Fig. 8) apparently did not meet, as they were in the Newcastle region at the same time, and would have had much of geological interest to discuss, specially as Leichhardt had more recently come from Europe where there had been an explosion of geological knowledge and ideas in the years since Strzclecki's departure. Leichhardt had already made a study of the coal measures in the vicinity of Newcastle (Fig. 9), and was, a little later to make important observations in what is now known as the Bowen Basin (Leichhardt 1855; Aurousseau 1968; Branagan op. cit.).

Fig. 8. Ludwig Leichhardt.

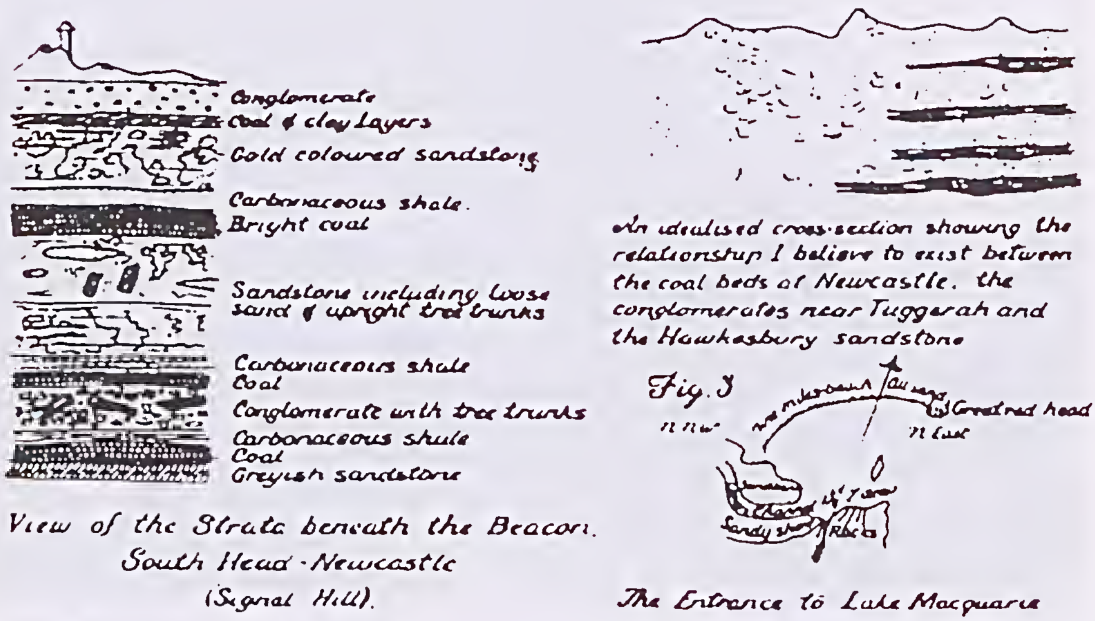

Fig. 9. Sketches by Ludwig Leichhardt.

Fig. 10. Joseph Beete Jukes.

However, Strzelecki was fortunate that Joseph Beete Jukes (Fig. 10), Naturalist on HMS *Fly*, was also visiting King at Port Stephens and the two geologists had a great time comparing Strzelecki's fossils with those depicted in Roderick Murchison's *Siluria* which King had in his library.

It is interesting that Strzelecki thought so highly of the geological section exposed along the coast at Newcastle that he included this in the frontispiece of his book. But no large scale version of this section is preserved and it seems clear that, before he left Launceston, Strzelecki had completed his sections which accompany his large map.

Strzelecki wrote to Franklin from Port Stephens on 19 December 1842. 'I have at last terminated what during four years, was the daily anxious aim of mine, namely the chart, the vertical sections and the descriptif [*sic*] part relating to the physical geography of Van Diemans [*sic*] and New South Wales.'

In the second section of the book he proposed different chapters each headed 'Glance on the Geological Phenomena which the [Different] series are presenting' (King 1843). The series were Primary, Transition, New Red Sandstone Group and Diluvial. Of the first three there was to be 'Description Mineralogical, Phisical [*sic*], Chemical and Geological of the Rocks'. In the case of the Diluvial the soils were to be described in terms of their 'Phisical [*sic*], Chemical and Agricultural Character'. Although fossiliferous rocks are mentioned in the proposed chapter on the Transition rocks, only in the content of the Diluvial chapter is there a proposed 'Description of mineralogical and fossiliferous content'. The two proposed sections on Botany and Zoology seem to have been intended only to discuss present-day organisms (see later).

STRZELECKI'S LATER LIFE

Strzelecki left Sydney on 22 April 1843, travelling via Canton and Suez, reaching London in late October. After he arrived in England he began to mix with Society, both social and scientific, thanks largely to introductions from Franklin and King, particularly to Sir Roderick Murchison (Fig. 11). In 1847 Strzelecki became involved in ameliorating the conditions of the starving peasants in Ireland during the potato famine. His non-British background probably gave him an advantage over the greatly disliked English bureaucracy, and his contribution, both in organisation and friendship, gained him universal praise. He became a naturalised British citizen and was honoured with a Knighthood in November 1848.

Strzelecki kept his interests in Australia in the 1850s through chairmanship of a subsidiary of the Australian Agricultural Co. (The Peel River Gold Co.), ensuring the appointment of a competent German geologist, Ferdinand Odernheimer, to examine its properties in New South Wales (Branagan 1984). He also, as mentioned earlier, became involved in the arguments about the discovery of gold in Australia, always keeping just on side with Sir Roderick Murchison, who also wanted some credit for it! (Strzelecki 1856; Stafford 1988, 1989).

Strzelecki had hoped that his work would be followed up officially quite rapidly, as he wrote to P. P. King (5 June 1845): 'there is a great probability I should be able to secure to the two Colonies a Government establishment called the Economic Geology, which will be a branch of the Office of the Ordinance [*sic*] Geological Survey of Great Britain under the direction of Sir Henry De la Beche—with a Geologist and a Chemist etc. etc. and through which a thorough Geological Survey of the two colonies will be made and such questions of chemistry and mineralogy solved, as

Fig. 11. Sir Roderick Murchison.

the development of mining and agriculture may require—as I have even recently declined the offer of an office in the Colonies and am far from angling for any at home, my representations have at least a weight of sincerity and disinterestness by which they are dictated, and are thus patiently listened to, in quarters which have a voice in the Chapter.' He added some words concerning the competition developing among coal mining groups in New South Wales, supporting King's thoughts on reducing the company price, noting 'I do really believe that in no part of the coal Basin there is such facility of extraction and shipment of coal as at the Company establishment.' He added that King had plenty of supporters in London 'Charles Stokes, Captain Beaufort I see frequently, Fitton & Stokes of the *Beagle* and other blue jackets' (King correspondence).

Although such a survey did not eventuate in New South Wales until 1850, when Samuel Stutchbury was appointed, Strzelecki tried hard to achieve his aim, writing a paper on mineral geography which included a proposal to set up a 'British Government Office to survey the geology of the colonies of Canada, New South Wales, Van Diemen's Land [Tasmania], New Zealand and

South Africa'. He sent the paper to Lord Grey on 14 January 1847 (Paszkowski 1997: 32). By this time William Logan was already at work in Canada, but the other colonies had to wait some years for geological surveys. Strzelecki and his persuasive powers were, shortly after, diverted to his work in Ireland.

Strzelecki died in London in October 1873 and is buried in Kensal Green cemetery. His name is remembered in Australia by the Strzelecki Ranges in Victoria, Mt Strzelecki in the Northern Territory, Strzelecki Peaks on the Furneaux Group in Tasmania, the Strzelecki Track in northeastern South Australia, and, of course by his naming of Mt Kosciuszko. There are now also various memorial plaques recording his achievements (see Rawson op. cit.; Paszkowski op. cit.).

STRZELECKI'S MAP AND GEOLOGICAL CONCEPTS

Strzelecki's published map of 1845 identifies only four main units (First, Second, Third and Fourth Epochs). However his original map, measuring 25 ft (7.6 m) long and 5 ft (1.5 m) wide and on a scale of ¼ of an inch = 1 mile (i.e. 1:250 000) and sections of the same scale, has at least 18 subdivisions (Fig. 12). His legend shows something of Strzelecki's geological background, borrowing, as it does, from Breislak and other continental sources. There are also considerable similarities with William Maclure's map of the United States first published in 1809 but revised in 1817 (Maclure 1817; Merrill 1964; Jordan 1979; Gerstner 1979). In some senses Strzelecki's map is firmly rooted in 18th Century time-scale concepts, which is perhaps not surprising, because the modern geological time scale was only just becoming established. There are also no firm boundaries on his large map, but this is also not surprising, in view of the country he covered (Branagan 1974, 1986a). Strzelecki's return to England in 1843 thrust him into the busy geological world of Murchison, Lyell and others, and with the help of palaeontologists he converted his ideas on age relations, to some extent, into what was becoming the established Palaeozoic, Mesozoic framework.

Strzelecki had discussed his fossils (Fig. 13) with J. B. Jukes when they were together at Port Stephens, and probably realised that they were the key to updating his material. It seems likely that Murchison advised him on whom to ask to examine his specimens. In 1842 Murchison, always keen to expand his 'Silurian Empire', had written to Governor Franklin asking him to send

Fig. 12. Strzelecki's original Geological Section of Mt Kosciuszko.

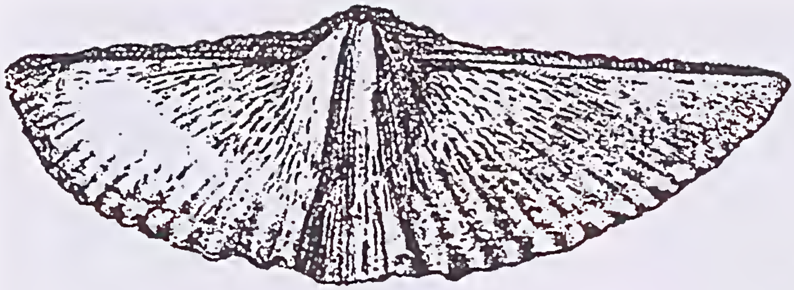

Fig. 13. Spirifer vespertilio (from Strzelecki 1845).

Fig. 14. John Morris.

fossils from Tasmania, commenting that Spirifers and Productids had been 'brought home by a mad Polish friend of yours' [this was, of course, not Strzelecki, but John Lhotsky] and having pushed the extension of the Palaeozoic 'from the remotest part of Europe into Asia I must try to do the same through my allies in the distant colonies and as you are one of my earliest playfellows in geology, I count upon your aid' (Murchison 1842).

Consequently in London, Strzelecki put the fossil plants and invertebrates in the hands of the experts John Morris (1810–1886) (Fig. 14), William Lonsdale (1797–1871) and George B. Sowerby (1788–1854), while Richard Owen (1804–1892) examined the vertebrates (including marsupials). Strzelecki was happy to accept their judgement and to place the older material in the Palaeozoic (and it probably pleased Murchison), although Morris

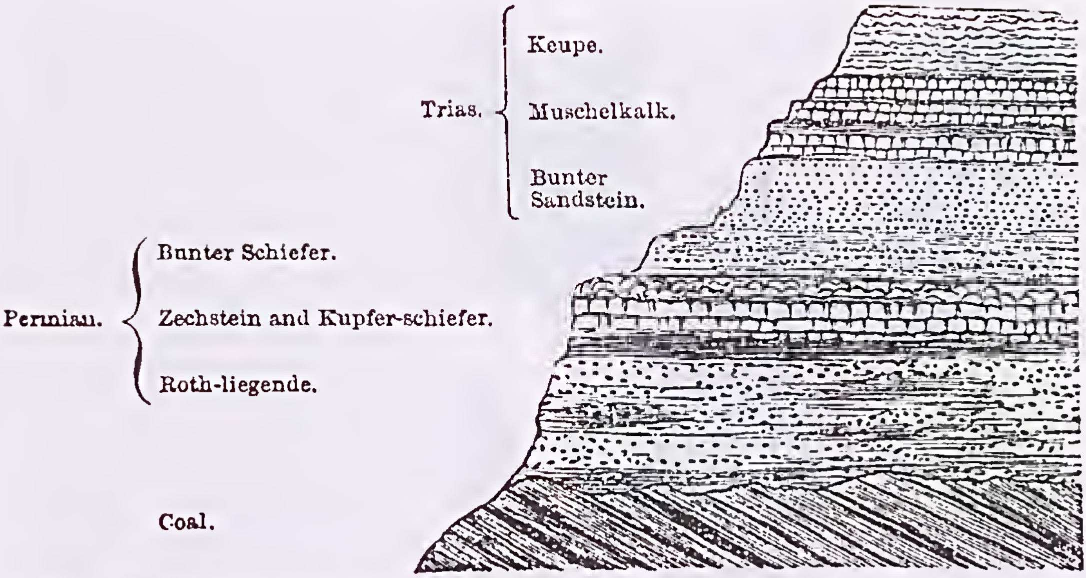

Fig. 15. Section of the Permian in Germany (Geikie 1875).

more specifically described the fossil plants as being Carboniferous. Lonsdale had already described the Tasmanian corals collected by Charles Darwin in Tasmania in 1836 (Darwin's Geological Observations).

Practical considerations meant that Strzelecki's huge map and sections could not be published. The need to produce a smaller map, and simpler sections, meant that Strzelecki was forced to abandon his quite complex lithological subdivisions, and the map used just four colors for the four epochs.

Thus we see a simple evolution of Strzelecki's major subdivisions from the preparation of his map and text in 1842 to its publication in 1845, as shown below:

Original Map (1842)	Text Proposal (also 1842)	Published Map and Text (1845)
Alluvial	Diluvial deposits	Fourth Epoch
Secondary	New Red Sandstone group	Third Epoch
Transition	Transition Series	Second Epoch
Primitive	Primary Series	First Epoch

THE PERMIAN CONCEPT

Sir Roderick Murchison first introduced the term Permian in 1841 in a letter to Dr G. Fischer de Waldheim of Moscow, the man who coined the word 'Palaeontology' (in 1834). Murchison wrote: 'the Carboniferous system is surmounted, to the east of the Volga, by a vast series of beds of marls, schists, limestones, sandstones and conglomerates, to which I propose to give the name of "Permian System" because, although this series represents as a whole, the lower new red sandstone (Rothe todte liegende) and the magnesian limestone or Zechstein, yet it cannot be classed exactly (whether by the succession of the strata or their contents) with either of the German or British subdivisions of this age. Moreover the British lithological term of lower red sandstone is as inapplicable to the great masses of marls, white and yellow limestones, and grey copper grits, as the name old red sandstone was found to be in reference to the schistose black rocks of Devonshire ...' Murchison mentions the presence of 'large accumulations of plants and petrified wood' and goes on to state: 'of the fossils of this system, some undescribed species of Producti might seem to connect the Permian with the carboniferous äera; and other shells, together with fishes and Saurians, link it on more closely to the period of the Zechstein, whilst its peculiar plants appear to constitute a Flora of a type intermediate between the epochs of the new red sandstone or "trias" and the coal-measures. Hence it is that I have ventured to consider this series as worthy of being regarded as a "System"'. In 1843 Murchison pursued the Permian rocks in Germany (Fig 15), accompanied by John Morris.

Fig. 16. (1) *Glossopteris browniana*; (2–4) *Pecopteris odontoperoides*; (5) *Zeugophyllites elongatus* (from Strzelecki 1845).

Murchison, Verneuil and Keyserling (1845) expanded on Murchison's earlier work on the new Permian system, describing 'a peculiar form of the carboniferous system and giving a detailed account of the coal-bearing tracts in the empire, by establishing under the name of "Permian" a copious series of deposits which form the true termination of the long palaeozoic periods. This last-mentioned system has not hitherto obtained the attention to which it is entitled. In France it is known only as a deposit of red sandstone with a few plants; in Belgium it is a mere conglomerate (the "Peneen" or sterile group of M. d'Omalius d'Halloy). In England and Germany, where its members are much more expanded in the form of red sandstone and conglomerate, magnesian limestone, copper, slate, etc., the strata have never received a collective name, nor have they till recently been united as a natural group*, distinguishable from the inferior formations by peculiar species, though connected with them by the general aspect of their fauna, and entirely different in all their organic contents from the overlying or triassic system.'

* The authors footnote that 'Professor Phillips was the first to maintain, that the fossils of the magnesian limestone of England ought to be classed with those of the palaeozoic rocks, and our Permian researches confirm his view'.

'Finding that this supracarboniferous group was not only spread over a region of enormous dimensions in Russia, extending from the Volga to the Ural Mountains on the east, and from the Sea of Archangel to the southern steppes of Orenburg, but that among certain fossils characteristic of the Zechstein in other parts of Europe, it also contained many new species of shells and a fauna somewhat differing from that of the carboniferous age, we have ventured to apply to it a collective name derived from the ancient kingdom of Permia, which was situated in the centre of the vast territories overspread by these deposits ... Such then is our apology for the introduction of a new synonym, and in the ensuing chapters we shall support our reasons for its use. To render, however, the term Permian acceptable to German and English readers, we have placed the words Zechstein and Magnesian Limestone as equivalents [in the Text and Map], thus to point out, that beds similar in structure to them, form part of the diversified "Permian System".'

They added: 'in our first announcement of this system we believed* that it might comprehend the Rothe-todte-liegende of Germany; but we have since seen reason to modify this view, and to exclude (for the present) that German deposit from our Russian natural group. For, if the rothe-todte-liegende should be found to contain (and we believe this to be the case) some of the same species of plants as the coal-fields of the surrounding countries, that deposit must certainly be considered the representative of the Carboniferous system in that portion of Northern Germany, where no other coal-fields exist. At all events, English geologists have not yet been able to point out any natural distinctions between the plants of their Lower Red Sandstone and those of the subjacent coal measures; and as the identification of this red sandstone with the rothe-todte-liegende has been admitted, we are compelled to avow, that a deposit so characterized can form no part of a system in which the plants belong to a peculiar type. In a word, therefore, our Permian system embraces everything which was deposited between the conclusion of the carboniferous epoch, and the commencement of the Triassic series.'

Willmarth (1925: 69) points out that the original definition of the Carboniferous by Conybeare and Phillips (1822) excluded what we now call the Permian, which was grouped with the Triassic in the 'New Red Sandstone' and Magnesian Limestone. However it included the 'Old Red Sandstone', which thanks to work by William Lonsdale in 1837 was defined in 1839 by Sedgwick and Murchison as Devonian (Sedgwick & Murchison 1839, 1840). Although there is usually an unconformity (better called a disconformity) between the Carboniferous and Permian in England, Germany and Netherlands, there is no sharp division in the USA, India and in Eastern Australia.

Murchison was not aware that the problem of coal in the Gondwana Permian succession was to complicate the unravelling of the Permian story in the Southern Hemisphere (and India).

Murchison certainly changed his mind several times between 1841 and 1845, as at the British Association meeting in 1843 he gave a paper entitled 'The Permian System as applied to Germany, with collateral observations on similar deposits in other countries, showing that the rothe-todte-liegende, Kupfer-Schiefer, Zechstein, and the lower portion of the Bunter-sandstein form one natural group, and constitute the upper member of the Palaeozoic rocks'.

THE AUSTRALIAN PERMIAN— A CHRONOLOGICAL DISCUSSION

Many significant aspects of the following section, particularly that referring to the Permian marine faunas of Australia, have been discussed by Archbold (1986). In a sense the Permian question in relation to Australia began with the collection of fossil plants in the Hunter River, New South Wales, and of a brachiopod near Hobart in 1804 by Robert Brown, the famous botanist, during the exploring expedition led by Matthew Flinders. The fossil plants were passed to William Buckland (1784–1856) and thence, after a long delay, ultimately went to Adolphe Brongniart (1801–1876), who recognised the plant as new to science and, in 1828, named it *Glossopteris browniana* (Fig. 16) although he thought it was probably

*They footnote an apology: 'Murchison's letter to Dr. Fischer, Moscow, Sept 1841, when the term "Permian" was first proposed; also Phil Mag vol. XIX, p. 417. In suggesting this name, we had, we confess, forgotten that our distinguished friend M. D'Omalius D'Halloy had employed the word "Péneen" to characterize all the strata between the "terrein houiller" and the "bunter sandstein". We adhere, however, to our geographical name, not only because it was adopted on the same principle which led to the use of "Silurian" and "Devonian", but also from our having found in the Permian deposits undescribed organic remains and much mineral wealth (copper, sulphur, salt etc.); thus rendering the word "Péneen" or "sterile" quite inapplicable in the present state of our knowledge.'

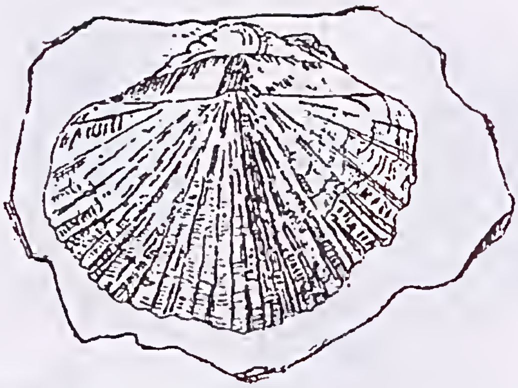

Fig. 17. Trigonotreta stokesii.

Fig. 18. Megadesmus species (from Mitchell 1838).

Mesozoic. *Glossopteris* was also present with Indian coals and appeared to be younger than European Carboniferous flora (but possibly still Carboniferous). The only problem was that Brongniart had already named as *Glossopteris* a fossil leaf from Jurassic rocks of Yorkshire! It was apparently acceptable for the same fossil to have different geological ages in Europe, Asia and Australia. Just a few years earlier T. H. Scott (1824) had suggested a relationship between *Glossopteris* and Eucalypts, which was followed up by Lesson (1826) suggesting that the sandstones of the Blue Mountains (now Triassic) were Tertiary because of the supposed close relation between the fossil plants and the present forms. Brongniart also described and named *Phyllotheca australis*.

The brachiopod collected by Brown was also neglected for many years, was described several years earlier than the *Glossopteris* leaves (in 1825) by Charles König, who noted its occurrence in ?Transition sandstone and named it *Trigonotreta stokesii* (Vallance, 1978) (Fig. 17) but this identification did not lead to the complications that ensued with the unravelling of the *Glossopteris* saga.

Thomas Mitchell's collections made between 1831 and 1836 were studied by William Lonsdale who attributed the Hunter Valley and Illawarra fossils to the Carboniferous (Fig 18). (Lonsdale expanded on this in 1851.) Mitchell in 1839 asked J. de C. Sowerby (1787–1871) to examine the shells he (and C. P. N. Wilton) collected from beneath the coal succession in the Hunter Valley. Sowerby suggested they could be correlated with fossils from the Mountain Limestone (Carboniferous).

Fossil brachiopods and molluscs collected by Lhotsky in Tasmania in the 1830s were sold by him to the British Museum, where Mitchell's fossils were also placed, but little attention seems to have been given to Lhotsky's specimens.

In 1840 M. de Verneuil described specimens obtained in Calcutta by the *La Bonite* expedition, but collected in Tasmania (Mt Wellington, New Norfolk and Port Dalrymple). He identified a productid, five spiriferids, a 'Great' Bivalve, a 'Great' Pecten and *Calamopora* and assigned them to the Carboniferous. The collection was also discussed by Chevalier (1846).

W. S. Macleay, more known for his zoological work, was quite knowledgeable about geology having contributed to Murchison's *Silurian System* on the trilobites, and acted as a useful 'devil's advocate' for the ideas put forward by his friend Rev. W. B. Clarke particularly on the ages of particular successions. Macleay (20 November 1843 to Clarke) made it plain that he thought the Sydney [i.e. Hawkesbury] sandstone was equivalent to the Gres des Vosges (early Triassic) and that the New South Wales Coal Measures were Palaeozoic. A little earlier Clarke had been inclined to assign both to the Oolitic. However by 15 April 1844 Clarke writing to MacLeay said 'the New South Wales coal measures are very low down and ... if not older, the youngest beds must be of the Millstone Grit. The fossiliferous beds below the coal of Newcastle and above the upper Hunter coal are charged with mountain-lime genera.'

Charles Darwin (1844), just anticipating Clarke, also called upon William Lonsdale to identify the corals he had collected in Tasmania, but his shells went to G. B. Sowerby. Darwin noted his discovery in the Wolgan Valley, west of Sydney of leaves of *Glossopteris browniana*, 'a fern which so frequently accompanies the coal of Australia'. Sowerby identified two species of Producta and six of Spirifera, noting that *Productus rugata* and *Spirifera rotundata* 'resemble, as far as their imperfect condition allows of comparison, British mountain-limestone shells'. Lonsdale identified six previously undescribed species of corals, belonging to three genera, and while species of these genera occurred in the Silurian, Devonian and Carboniferous strata of Europe, Lonsdale felt that they were younger than Silurian. While the Palaeozoic character of the fossils was confidently asserted, the considerable thickness ('at least 1000 ft') and variability of the succession suggested a considerable time span.

Strzelecki's collection and the dating have been discussed above.

L. G. de Koninck (1809–1887) (see Vallance 1975: 33) in 1846 anticipated Dana's recognition of Permian rocks in Australia (based on Newcastle fish, possibly collected by C. P. N. Wilton) in a throwaway note about invertebrates beneath Australian coal in a paper concerned with fossils from Spitzbergen!

The collections made by Rev. W. B. Clarke between 1839 and 1846 were examined by Frederick M'Coy in 1847, but John Morris expressed uncertainty about the plants which, the following year, M'Coy (1823–1899) suggested as Jurassic.

Dana (1849), having recognised the Permian character of fossiliferous rocks in both the Wollongong area (Fig. 19) and the Hunter Valley, described and illustrated a number of characteristic fossils which he had collected nearly ten years earlier, comparing them with those described in Strzelecki's book. Some of the sites had been noted and collected from even earlier by Rev. Richard Taylor (1836) who wrote 'we examined a remarkable micaceous sandstone formation at a place called Bells Creek which was completely filled with a species of encrinite lilly. We afterwards rode to Harpurs Hill where we left our horses at the Stockade, whilst we examined the hill which appeared chiefly to consist of green sandstone strangely intermixed with round balls of bazalt some of large dimensions, it appeared as if the whinn stone had pushed up the sandstone, and thus caused the strange mixture, the latter contained many univalves and bivalves; I noticed the belemnite, a trochus similar to one found on these shores and a patella, nearly corresponding with one found on the shore at Newcastle, also a muscle, we took some refreshment here after having beaten about the rocks for three whole hours to the evident astonishment of the Ironed gang at work there who doubtless saw little pleasure in such amusements' (Taylor 1836). Unfortunately the fossils mentioned by Taylor, and possibly collected, were not examined and described by a palaeontologist.

Dana (1849) was somewhat more scientific in discussing 'Fossils of the Sandstone below the Coal, and age of the deposits', writing:

> 'Fossil shells, along with some corals, occur at many localities of the argillaceous sandstone ... Harper's Hill and Glendon are localities on the Hunter already somewhat noted in the colony. The shells throughout are well preserved, the valves are united with unbroken edges or angles, (except from pressure), and the ridges or markings are distinct and apparently unworn. The bivalves usually lie with the valves somewhat gaping, though sometimes closed. Numbers of the same species are often clustered together. The shells are fossilised either with lime or silica. The former is the case at Harper's Hill; and the shells look as fresh and white, and as natural, as if just from the water. They are so neatly preserved, that, judging from this character alone, they might easily be mistaken for fossils of a modern date. When broken across, a cleavage structure is often exposed, showing that the original lime of the shell has been recrystallized. If, as the writer has suggested in another place, the lime of shells is in the condition of aragonite, we may under-

Fig. 19. Dana's sketch geological map of the Wollongong area.

stand how a molecular change should take place, producing the ordinary calc spar and its cleavage. The striae or markings of the original shell are perfectly retained.

'... The fossil animal remains embrace a variety of genera, including some that have hitherto been considered as widely distant in geological age. The whole number of species obtained by us is eighty-six, of which there are nine or ten corals, two of Conularia, one of Theca, sixty-four of bivalve molluscs, and eleven of univalves.

'The specimens of these localities may generally be distinguished by the nature or colour of the rock accompanying them. Those of Harper's Hill are calcareous fossils, and the rock has an olive green colour, generally appearing somewhat granular. Those of Glendon, seen by the author, have mostly a rusty ferruginous look, and the rock is somewhat schistose ...

'The species of fossils of the different genera, are as follows:– ... From Harper's Hill.— 3 species of Bellerophon, 3 Platyschisma, 2 Pleurotomaria, 1 Conularia, 1 Spirifer, 1 Solecutus, 1 Maeonia, 1 Nucula, 2 Eurydesma, 2 Cyprocardia?, 3 Pecten, 3 Pachydomus, 1 Chaetetes, 1 Hemitrypa?* [Dana thought that some of the localities had been confused by Strzelecki.]

'No species of Harper's Hill and Illawarra proved to be identical, excepting the *Pleurotomaria morrisiana* and the *Spirifer glaber*. The Conulariae are peculiar to Harper's Hill ... The Glendon fossils are also peculiar; of them, only a single Spirifer was found also at Illawarra.'

Ludwig Leichhardt also made observations at Harper's Hill, Glendon, and Singleton, recording some information on sections (Fig. 9) (Leichhardt 1855; Branagan 1994).

J. B. Jukes's map, published in 1850 (prepared four years earlier), is restricted essentially to the coastline, except in the southeast of the continent, where it relies on Strzelecki and others. However it shows no Secondary rocks, only Tertiary (and supposed Tertiary), Palaeozoic (and supposed Palaeozoic) are given by age. In the text Jukes refers to Silurian, Devonian and Carboniferous periods, but sees it as pointless to attempt to identify such rocks in Australia with the knowledge available. Metamorphic rocks are shown separately, and there are two groups of basalt (and related rock types). However Jukes warns the reader not to expect any accuracy of outline. 'They are not geological maps in the strict sense of the word, the geological colours being only dabbed on roughly about the place where the rock indicated by it was observed, as nearly as I could guess its size and locality. The colours are only intended to come in aid of the description, and to guide the eye and help the memory.'

Jukes (1850) refers to the coals as Palaeozoic, but makes no attempt to go into further detail of age. He may have been partly responsible for one aspect of the controversy by referring to 'palaeozoic rocks, with coal, occur around Western Port, and are found in highly inclined positions at some points around Port Phillip where horizontal tertiary strata rest upon them'. However Jukes hints at the coal problem, writing: 'some persons have been struck with the oolitic aspect of the fossil plants collected in New South Wales (as also of those of India), and have been led to imagine, in consequence, that they did not belong to the same formation as that in which the productae, spiriferae, etc. are found'. Jukes goes on to say that he sees 'the whole series as one great continuous formation'. A. R. Selwyn, Government Geologist of Victoria from 1852, was to be dogged by the coal question, as the age had definite economic implications. Younger coals were usually much poorer fuels and industrialists expected Selwyn to come up with the better material (Zeller & Branagan 1994).

Jukes suggests that the marine fossils are similar to those in the Devonian formations of Europe, but he hastens to add that formations on opposite sides of the world need not be strictly synchronous. He adds a footnote 'there is a certain resemblance between the fauna and flora now living in Australia and those found fossil in our oolitic rocks'. In his general summary Jukes notes the 'total absence of any rocks of an age intermediate between the palaeozoic and the tertiary, so far as is at present known'. Here we see that Jukes was tending to get away from the idea that European geology was a model for the world. Leichhardt also was clearly aware of the difficulties of accepting such an idea. This 'out-of stepness' continued to have repercussions in Australian geology well into the 20th Century (Branagan 1986b).

Grange (1854) in writing up the geology of Dumont D'Urville's *Voyage au Pole Sud* relies to a great extent on Strzelecki's published work and

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*According to Strzelecki, there are other species common to Illawarra and Harper's Hill; but we may doubt his accuracy, for reasons already stated.

Fig. 20. Alcide D'Orbigny.

the identification of fossils by Lonsdale and Morris, but with the addition of other identifications by J. de C. and G. Sowerby from Mitchell and Darwin, and an illustration of fossil shells determined by Alcide D'Orbigny (1802–1857) (Fig. 20). Grange reports the collection, at several sites in Tasmania, of *Spirifera stokesii* (König), noted by Morris (in Strzelecki) as a synonym for *Trigonotreta stokesii.* Most of the invertebrate fossils were collected from sites now known as Permian or Carboniferous, with a brief mention of sites near Orange and Yass in New South Wales containing presently recognised Silurian fossils, but the younger strata are separated into Secondary and Tertiary epoch material, essentially at the base of the coal measures. Grange notes in particular an unconformity at Cullen Bullen between first and second epochs, which is today recognised as being at the base of the Sydney Basin Permian succession.

We see the continuation of a long controversy, what Vallance (1981) called the Fuss about Coal, in the legend of the first nearly complete Map of Australia, prepared by Robert Brough Smyth in 1873. Smyth, working from Melbourne, called for information from authorities in the various colonies to prepare the map. The key point in the Legend of the map is the term 'Carbonaceous'. This is Smyth's 'Escape Clause'. A long debate had ensued, mainly between Rev. W. B. Clarke of New South Wales and Frederick M'Coy who had moved to Victoria as Professor of Natural Science in 1854 (both being protégés of Adam

Sedgwick of Cambridge), as to the age of Australia's coal measures. The argument was based on both stratigraphy and fossils, and as in many arguments, both sides were partly right, but Clarke probably more so than McCoy. Were the coal measures Carboniferous, like the main deposits of Europe, or Mesozoic, such as were found in Yorkshire?

Part of the problem was that McCoy was seeing evidence mainly from Victorian black coals, which in fact are mainly Jurassic, while Clarke was studying New South Wales coals, which he believed were Carboniferous, but which we now know are Permian. A further complication was that Clarke carried out a considerable amount of fieldwork, studying the field relations of the coal beds and the associated sedimentary rocks, while McCoy, not a particularly good field geologist, relied almost entirely on fossil specimens, examined in the laboratory, some of them, in the earlier years, collected by Clarke. This argument drew in many Australian geologists, Selwyn and Richard Daintree from Victoria taking the trouble to visit Clarke's key sites in the Hunter Valley.

The term Permian receives few direct mentions over the years from 1849 to 1890, with the exception of comments such as Selwyn's (1861) assigning the Bacchus Marsh successions to a period intermediate between the Carboniferous and Permian (see Archbold 1998), and J. E. T. Woods's (1883) placing of the lower *Glossopteris*-bearing beds of New South Wales in the Permian.

Otakar Feistmantel (1848–1891) (Fig. 21), who never visited Australia, still played an important role in the history of research on the Gondwana System (Haubelt 1994). Feistmantel gained useful experience with Hans Geinitz on the Saxonian Permian and Carboniferous, with Heinrich Goeppert on the Palaeozoic of Prussian Silesia, and Carl Roemer on the coal deposits of central Europe in the early 1870s. In March 1875 he and his wife travelled to India where he spent eight years. Central to the present paper is his *Palaeozoische Flora des östlichen Australien*, published 1878–79, which came after much of the Fossil Flora of the Gondwana System in India (Feistmantel 1876–1886) was published in English. Because of the essentially terrestrial nature of much of the sedimentation in the late Permian and early Triassic Australian succession Feistmantel's work on palaeobotany was crucial to the eventual understanding of the geological history of the southern continents in this portion of geological time.

Feistmantel's work became more readily accessible to English-speaking geologists with the publication (1887, 1890) of *Geological and Palaeontological Relations of the Coal and Plant-bearing Beds of Palaeozoic and Mesozoic Age in Eastern Australia and Tasmania*. Feistmantel also produced *Coal-bearing Formations in Tasmania* (1890), which is in Czech, and therefore less known. In this work he analysed a set of fossils, sent to him by T. Stephens of Hobart, defining a Palaeozoic Mersey Zone and a Mesozoic Jerusalem Zone. This led him to suggest that Tasmania was the cradle of Mesozoic flora, which then spread. However Feistmantel's ideas probably became better known from the fourth edition of Rev. W. B. Clarke's *Sedimentary Formations of New South Wales* in 1878, in which a manuscript letter from Feistmantel dated 26 February 1878 was printed as appendix XX. This included an extensive table of correlation of Australian non-marine fossils. In this letter Feistmantel queried the correlation of the Newcastle coal measures with those of India, believing that the Indian coals were Lower Triassic and not late Palaeozoic. He was not convinced of the Palaeozoic age of the Newcastle beds in 1881, assigning them to the Lower Trias, but by 1887 placed them in what became a catchall 'Permo-Carboniferous' group.

Fig. 21. O. Feistmantel (Kettner 1966).

The term 'Permo-Carboniferous' seems to have been first introduced by R. Etheridge Jnr (Fig. 22) in 1880, and became widely used following the publication of Etheridge's Memoir in 1891 and Etheridge and Jack's *Geology and Palaeontology of Queensland and New Guinea* the following

Fig. 22. R. Etheridge Jnr.

Fig. 23. T. W. E. David.

Fig. 24. L. G. de Koninck.

year. T. W. E. David (Fig. 23) (1893, 1898) summarised the major palaeontological reasons for separating the definite Carboniferous forms from younger material. The term persisted beyond 1914 (David 1914), because of its practical value, although David was convinced that the successions included were essentially all Permian. By 1932 the term was abandoned (David 1932), and the base of the succession was confidently placed at the base of the *Eurydesma cordatum* horizon.

Some of the previous story can be gleaned from the appendices to the fourth edition of Clarke's *Sedimentary Formations of New South Wales* published in 1878, where the significant fossils are named. More detailed systematic on Australian palaeontology began about this time. In parallel with the Feistmantel reports on fossil flora L. G. De Koninck (Fig. 24) completed his classic study of marine fossils *Recheches sur les fossiles paléozoiques de la Nouvelles-Galles du Sud* in 1877. These were based on fossils (Fig. 25) collected by Clarke, which were returned to him after the work was completed. They were among material destroyed in the Garden Palace fire in 1882. T. W. E. and C. David translated the section dealing with 'Carboniferous and Permo-Carboniferous' in the early 1880s, and a complete translation was published in 1898. In the meantime Robert Etheridge Jnr had published (1891) his descriptions of Palaeozoic corals and bivalves, which included what became the generally accepted classification of the rock succession (Fig. 26)

CONCLUSION

In his 1893 address to AAAS Ralph Tate said 'no prejudices or scholastic disputations have retarded our progress [in Geology], for those who have aided in the work were disciples of the modern school.' It is a wonderful piece of work, and is an essential paper for anyone studying the history of geology in Australia. However, as Vallance (1975) has pointed out, the history of geology in Australia is a continuing series of interesting disputations, not least of which is the story of the unravelling of the Permian system. Nevertheless Tate's address is a magnificent review of research publications, summing up the work of explorers,

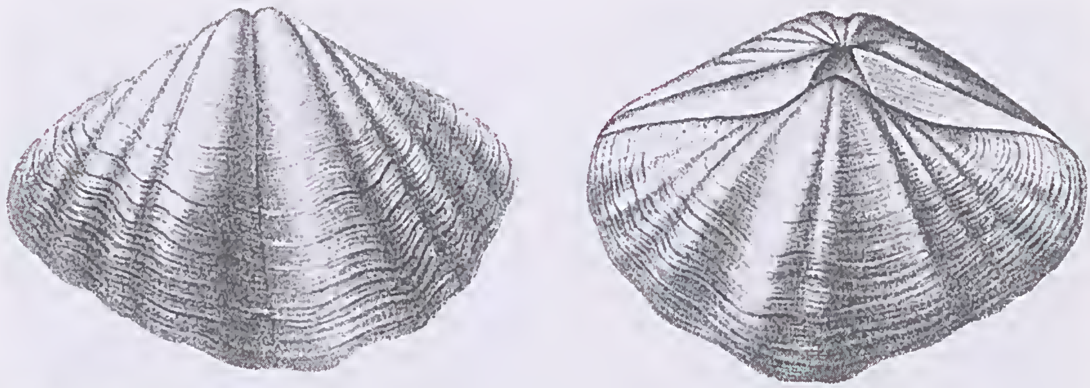

Fig. 25. Spirifer strzeleckii.

government officials, surveys and individuals over more than sixty years. In the present context it must be acknowledged for its recognition of the part played by Strzelecki '[who] laid the foundation of stratigraphical geology in Australia'. Tate's paper also notes the essentially multicultural contributions to the growth of Australian geology, brought out more clearly by Vallance (op. cit.), and of which Sir Paul Edmund Strzelecki is an outstanding example.

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THE Carboniferous and Permo-Carboniferous Formations of N. S. Wales.

	Hunter River Coal-field.	Illawarra Coal-field.	Blue Mountain and Lithgow Coal-field.	Mittagong Coal-field.	Gunnedah or Namoi Coal-field.
PERMO-CARBONIFEROUS. Upper Coal-Measures	*Newcastle Group.* Productive Coal-Measures, with *Glossopteris*, &c.	*Bulli Group.** ditto	*Lithgow Group.** ditto	*Mittagong Group.** ditto	*Namoi Group.** ditto
	Dempsey Group. Barren fresh-water beds.	(Unproven.)	(Unproven.)	(Unproven.)	(Unproven.)
Middle Coal-Measures	*Tomago, or East Maitland Group.* Productive Coal-Measures, with *Glossopteris*, &c.	(Unproven.)	(Unproven.)	(Unproven.)	(Unproven.)
Upper Marine Series	1. Mulbring beds. 2. Muree Rock. 3. Branxton beds, with erratics.	1. Encrinital Shales. 2. Nowra Grit. 3. Conjola beds.	Wallerawang beds.		
Lower Coal-Measures	*Greta Group.* Productive Coal-Measures, with *Glossopteris*, *Vertebraria*, &c.	*Clyde Group.* ditto	(Hidden by overlap.)	(Hidden by overlap.)	(Hidden by overlap.)
Lower Marine Series ...	*Farley Group.*	(Unproven.)	(Unproven.)	(Unproven.)	(Unproven.)
	Unconformity?	*ditto*	*ditto*	*ditto*	*ditto?*
CARBONIFEROUS ...	1. Rhacopteris beds. 2. Marine beds, with *Productus*, *Conularia*, &c. 3. Rhacopteris and Lepidodendron beds.	(Unproven.)	Rhacopteris and Lepidodendron beds.	(Unproven.)	Lepidodendron beds of Goonoo Goonoo.
	....	....	*Unconformity!*	....	....
DEVONIAN	....	....	Mt. Lambie Sandstones and Quartzite.	....	....
SILURIAN	....	Yalwal Slates.	....	Marulan Limestone.	....

* This classification is provisional: the Group may have to be classed with the Middle Coal-Measures.

Fig. 26. Stratigraphic table by Etheridge (1891).

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